REMARKS

Response to §112 Rejection

In the October 18, 2005 Office Action, the Examiner rejected claims 31 and 32 under 35 U.S.C. §112, second paragraph. Specifically, the Examiner asserted that claims 31 and 32 both recited a broad range or limitation together with a narrow range or limitation, in alleged violation of MPEP §2173.05(c) (see Office Action, page 2, last paragraph).

Applicants respectfully traverse the Examiner's rejection of claims 31 and 32 for the following reasons:

MPEP §2173.05(c) prohibits recitation of a narrow range that falls within a broader range "in the same claim," but it expressly provides that a narrower range or preferred embodiment may be set forth either "in another independent claim" or "in a dependent claim."

In the present invention, neither claim 31 nor claim 32 recites a broader range and a narrower range in the same claim. Instead, the broader range is recited by claim 24, from which claims 31 and 32 depend. Claims 31 and 32 therefore are merely dependent claims that each recites a narrower range, which are consistent with the provision of MPEP §2173.05(c).

Applicants thus request the Examiner to withdraw the §112 rejection of claims 31 and 32.

Allowable Claim 32

In the October 18, 2005 Office Action, the Examiner stated that claim 32 would be allowable if rewritten in independent form to overcome the §112 rejection (see Office Action, page 7, third paragraph).

In response, Applicants have hereby rewritten claim 32 into independent form, consistent with the Examiner's suggestion. Therefore, claim 32, as amended, is allowable.

Response to the §103 Rejection

In the November 18, 2005 Office Action, the Examiner rejected claims 24, 25, and 28-31 under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,810,924 to Legoues et al. (hereinafter "Legoues"), in view of U.S. Patent No. 6,165,903 to Besser et al. (hereinafter "Besser") and U.S. Patent No. 3,855,612 (hereinafter "Rosvold").

Applicants respectfully traverse the Examiner's §103 rejection of claims 24, 25, and 28-31, for the following reasons:

Claim 24, from which claims 25 and 28-31 depend, positively recites:

> "24. An electrical contact to a region of a silicon-containing substrate comprising a substrate having an exposed region of a silicon-containing semiconductor material; and a first layer of Ni monosilicide, wherein said substrate and said first layer are separated by a Si-Ge interlayer and **said first layer of Ni monosilicide comprises at least one additive selected from the group consisting of C, Al, Sc, Ti, V, Cr, Mn, Fe, Co, Y, Zr, Nb, Mo, Ru, Rh, Pd, In, Sn, La, Hf, Ta, W, Re, Ir, Pt, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Tb and Lu**."

In the October 18, 2005 Office Action, the Examiner expressly conceded that the primary reference Legoues fails to teach or suggest a Ni monosilicide layer that comprises at least one of the additives as recited by claim 24 of the present application, but attempted to remedy the deficiency of Legoues by citing the secondary references Besser and Rosvold.

However, neither Besser nor Rosvold discloses a Ni monosilicide layer that comprises at least one of the additives as recited by claim 24 of the present application.

Besser discloses only a low resistivity nickel monosilicide (NiSi), but it fails to teach or suggest that the nickel monosilicide (NiSi) layer comprises at least one of the additives as recited by claim 24 of the present application.

On the other hand, Rosvold discloses only a ternary compound that is formed by heating an alloy of platinum and nickel (i.e., platinel) on a silicon surface, which effectuates alloying between the silicon and the platinum and nickel (see Rosvold, column 1, lines 46-55), but it does **not** expressly disclose that the ternary compound contains nickel monosilicide.

It is known that nickel silicide has many phases with different resistivity, among which nickel monosilicide is the desired phase with low resistivity for electrical contacts (see Shanmugam et al., Suppression of High Resistance Phases of Nickel Silicide for Sub-100 nm Si CMOS, downloaded from http://ecsmeet.peerx-press.org/ms_files/ecsmeet/2005/01/03/00024380/00/24380_0_art_file_0_1104772081.pdf#search='Shanmugam%20and%20nickel%20and%20silicide' on January 5, 2006, a copy of which is enclosed herewith).

However, Rosvold expressly teaches that the nickel silicide contained in the ternary compound has a "**very, very high**" contact resistance (see Rosvold, column 7, lines 6-10). Therefore, the ternary compound disclosed by Rosvold contains high resistance phases of nickel silicide, instead of the low resistivity nickel monosilicide as expressly recited by claim 24 of the present application.

In the October 18, 2005 Office Action, the Examiner asserted that it would have been obvious to combine the teachings of Besser, Legoues, and Rosvold, i.e., to add an additive such as platinum to nickel monosilicide to form an electric contact.

However, in establishing a *prima facie* case of obviousness, the Examiner must show: (1) there is some suggestion or motivation to modify or combine the reference teachings; (2) there is a reasonable expectation of success; and (3) the prior art references must teach or suggest all the claim limitations. More importantly, the teaching or suggestion to combine and the reasonable

expectation of success must both be found in the prior art, not in applicant's disclosure. In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (1991).

In this case, the combination of the Besser, Legoues, and Rosvold references as proposed by the Examiner is not supported by any reasonable expectation of success found in the prior art. Specifically, the Besser, Legoues, and Rosvold references do not provide any reasonable expectation of success that the nickel monosilicide, which is disclosed by Besser, can be formed in the presence of the platinum additive disclosed by Rosvold. On the contrary, Rosvold teaches only formation of high resistance phases of nickel silicide, instead of the low resistivity nickel monosilicide, in the presence of platinum additive.

Therefore, the Examiner has failed to establish a *prima facie* case of obviousness against Applicants' claimed invention. Correspondingly, Applicants respectfully request the Examiner to withdraw the §103 rejection of claims 24, 25, and 28-31.

Addition of New Claim 33

Applicants have hereby added a new claim 33, which recites: "[a]n electrical contact to a region of a silicon-containing substrate comprising a substrate having an exposed region of a silicon-containing semiconductor material; and a first layer of Ni monosilicide, wherein said substrate and said first layer are separated by a Si-Ge interlayer and said first layer of Ni monosilicide comprises at least one additive selected from the group consisting of C, Al, Sc, Ti, V, Cr, Mn, Fe, Co, Y, Zr, Nb, Mo, Ru, Rh, Pd, In, Sn, La, Hf, Ta, W, Re, Ir, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Tb and Lu." Support for the new claim 33 can be found in the previously entered claim 24.

Note that Pt has been specifically excluded from the Markush group of additives recited by the new claim 33.

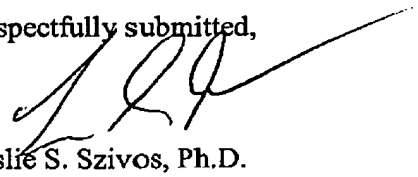
Therefore, claim 33 patentably distinguishes over the cited references, by reciting a nickel monosilicide layer that comprises at least one additive selected from a group of additives that is not taught or suggested in any manner by the cited references.

CONCLUSION

Based on the foregoing, claims 24, 25, and 28-33, as amended herein, are in condition for allowance. Issue of a Notice of Allowance for the application is therefore requested.

If any issues remain outstanding, incident to the formal allowance of the application, the Examiner is requested to contact the undersigned attorney at (516) 742-4343 to discuss same, in order that this application may be allowed and passed to issue at an early date.

Respectfully submitted,



Leslie S. Szivos, Ph.D.
Registration No. 39,394

Scully, Scott, Murphy & Presser
400 Garden City Plaza, Suite 300
Garden City, New York 11530
(516) 742-4343 (phone)
(516) 742-4366 (facsimile)
LSS/MY

Suppression of High Resistance Phases of Nickel Silicide for Sub-100 nm Si CMOS

J. Shanmugam, J. Zhu and M. Tao*
Department of Electrical Engineering, University of Texas at Arlington
Arlington, Texas 76019, USA
*Email: mtao@uta.edu

Nickel silicide has many phases with different resistivity, among which nickel monosilicide (NiSi) is the desired phase with low resistivity for electrical contacts to the source, drain and gate of sub-100 nm Si CMOS devices. The high resistance phases of nickel silicide are formed at relatively low annealing temperatures below 400°C, while low resistance nickel monosilicide is formed above 400°C [1]. In this study, we demonstrate the suppression of high resistance phases of nickel silicide at annealing temperatures up to 500°C, which is accomplished by atomic-scale engineering of the Si(100) surface. Transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS), four-point probe and X-ray diffraction (XRD) are some of the techniques used to verify the suppression of high resistance phases of nickel silicide at temperatures up to 500°C.

Both TEM and XPS suggest that high resistance phases of nickel silicide are suppressed below 500°C and low resistance nickel monosilicide is formed above 500°C on the atomically engineered Si(100) wafer. XRD reveals the various phases of nickel silicide formed between 200°C and 700°C. For 500-Å nickel on n-type 10^{15} cm^{-3} atomically engineered Si(100) wafers, four-point probe shows that the sheet resistance stays low at ~2.5 Ω/□ below 500°C, while that of the control wafer jumps to ~8 Ω/□ between 250°C and 350°C. Therefore, high resistance phases of nickel silicide are suppressed. Between 550°C and 750°C, the control wafer still shows ~10% higher sheet resistance.

[1] T. Morimoto et al. IEEE Trans. Electron Devices 42, 915 (1995).